Overload Effect on Fatigue of AerMet 100 Steel

E. U. Lee* and K. Sadananda**

Overloads have been reported to perturb the steady state fatigue crack growth condition and retard the crack growth. The retardation effect is known to depend on material plasticity, slip planarity, microstructure, overload ratio, and background stress intensity range ΔK and load ratio R. Extensive studies have been conducted to identify the effect of a single overload (or spike load) in terms of the number of delayed cycles.

This study was initiated to understand the effect of a single overload on the threshold fatigue crack growth in AerMet 100 steel as a function of R-ratio and environment. A single 100% overload (or overload ratio 2) was applied after the fatigue crack growth rate da/dN reached the threshold one (5×10^{-10} m/cycle) in the K-decreasing test of load shedding. The background load and the corresponding overload were stepped up until the crack began to grow after each loading of 5×10^{-5} cycles. Subsequently, the fatigue test was continued under constant amplitude loading at various R-ratios, ranging from –1.1 to 0.9, and frequency of 10 Hz in air and vacuum of 5×10^{-8} torr. The overload-induced increase in the threshold stress intensity range ΔK_{th} was taken as the measure of overload retardation effect. Furthermore, the overall results were analyzed in terms of two parameters, ΔK_{th} and maximum stress intensity at threshold K_{max}.

Under background load in air, with increasing R-ratio, the ΔK_{th} changed little for $R < 0$, but it decreased linearly for $R = 0$ to 0.5 and then leveled off for $R > 0.5$. The corresponding K_{max} changed a little for $R < 0$ but increased steeply for $R > 0$ with increasing R-ratio. After a 100% overload in air, the ΔK_{th} increased linearly for $R < 0$ but decreased for $R > 0$ with increasing R-ratio. The feature of the corresponding K_{max} change with R-ratio was similar to that for the background load, except the K_{max} was increased by overload.

Under background and after a single overload in vacuum, ΔK_{th} decreased linearly with increasing R-ratio for $R > 0$. The overload-induced increase in ΔK_{th} was less in vacuum than in air.

The fundamental threshold curve of ΔK_{th} vs K_{max} indicates that (a) the resistance to fatigue crack growth is greater in vacuum than in air under the background load and after a single overload, but (b) the overload retardation effect is greater in air than in vacuum.

The related fractography, crack path and crack tip geometry were examined for the fatigue tests.

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14. ABSTRACT

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